Brachiopoda	Mr. Davidson.
Higher Crustacea	Probably Prof. Claus.
Ostracoda	Prof. G. Brady.
Copepoda	
Isopoda	Mr. Henry Woodward.
Cirripedia	Mr. Darwin.
Annelida	Dr. McIntosh.
Gephyrea	Prof. Ray Lankester.
Bryozoa	Mr. Busk.
Echinoidea	Mr. A. Agassiz.
Ophiuridea	Mr. Lyman.
Crinoidea	Dr. Carpenter and myself.
Hydromedusæ	Prof. Allman.
Corals	Mr. Moseley.
Sponges	Prof. Oscar Schmidt and myself
Rhizopods	Mr. Henry Brady.
Radiolarians	Prof. E. Haeckel.

"Now the only foreigners in this list are Dr. Günther, Prof. Claus, Prof. Agassiz, Mr. Lyman, Prof. Oscar Schmidt, and Prof. Haeckel. If there is a better English authority than Dr. Günther on fishes, I beg his pardon for having overlooked him. The crustaceans were to have been done by the late Dr. v. Willemöes-Suhm and certain considerations come in as to the use of his plates and notes, which I need not discuss. I am not aware that there is any one in this country who can be considered at present an authority on recent Echinoidea. The choice perhaps lay between Agassiz and Lovén, but the reference collection at Cambridge is the best in the world in this department. There is, so far as I know, no English authority on Ophiurids at present. I prefer Oscar Schmidt's mode of treating the sponges to that of any other author. I am not aware that any Englishman knows the Radiolarians so well as Haeckel. There are a good many departments not yet settled, and one or two other foreigners may be added to the list. I should of course have most heartily asked your assistance with the corals had Moseley not undertaken them, but he has the preference as one of our staff, and he has done excellent work.

"I have submitted the principles on which I am working to the best of my ability to the Treasury, and they have received their sanction and that of the Council of the Royal Society. I cannot recognise the importance of the geographical distribution of naturalists, and with all respect for the dignity of British science I must say I think that in this selection, which I considered entirely open, I have done it ample justice.

"Believe me, very truly yours,
"C. WYVILLE THOMSON

"20, Palmerston Place, Edinburgh, March 27"

To this letter no reply has been received, and the subject might well have ended here.

The objectors to the course pursued by Sir Wyville Thomson would hardly advocate our assumption of a spirit more narrow and illiberal than that of any other country, and they will perhaps be interested in knowing how a foreign Government has acted under quite similar circumstances.

The results of the two great recent scientific expeditions fitted out in the United States, that of the "Haslar," and the Exploration of the Gulf Stream, have been distributed among special workers without any regard to nationality. Of this we need no further evidence than that afforded by the arrangements which have been adopted for the examination of the very rich collections made during the Gulf Stream Expedition. These collections have been allocated as follows:—

Halcyonaria	A. Kölliker	Würzburg.
Annelides	E. Ehlers	Göttingen.
Sponges (part)	O. Schmidt	Strassburg.
Sponges (part)	E. Haeckel	Jena.
Holothurians	E. Selenka	Leiden.
Polyzoa	F. A. Smitt	Stockholm.
Mollusca	J. Gwyn Jeffreys	London.
Hydroids	G. J. Allman	London.
Starfishes	E. Perrier	Paris.
Crustacea	Alph. Milne Edwards	Paris.
Fishes	F. Steindachner	Vienna.
Cephalopods	J. P. Steenstrup	Copenhagen.
Brachiopods	W. H. Dall	Washington.
Corals	L. F. Pourtales	Cambridge, U.S.
Ophiurans	T. Lyman	Cambridge, U.S.
Echini	A. Agassiz	Cambridge, U.S.

It will be thus seen that out of the twenty-two zoologists among whom the collections of the *Challenger* have been distributed *seventeen are English;* while out of the sixteen to whom the American collections have been assigned, *four are American.*

ELEMENTARY PHYSICS

Matter and Motion. By J. Clerk-Maxwell. (Society for Promoting Christian Knowledge. London, 1876.)

THE recent appearance of a swarm of elementary books on physics, some of which at least are written by well-known authors, leads to some very curious inquiries and speculations: for, though treating in the main of the same parts of the same subject as does the work we are specially dealing with, and addressed professedly to the same class of readers, they have comparatively little in common with it. To a certain, even a considerable, extent, this difference is of course due to the idiosyncrasies of the authors; but, after all allowance is made for these, there is still a most notable divergence. It will be both interesting and profitable carefully to consider in what this divergence consists, and what is its probable origin. For it is not too much to say that an intelligent reader of Clerk-Maxwell's book, had he no other source of information, would be utterly unable to answer any one of hundreds of questions which might be framed (without "dodge" or "trap") by a qualified examiner, *directly* from the text of the others. It is true that such questions would be artificial rather than natural—bearing more upon old and cumbrous dogmatic fallacies than upon the actual facts of science. But if the reader of Clerk-Maxwell's book would be at a loss when examined from any of the others, the student who relies merely upon one (or even *all*) of these would hardly even understand the meaning of a question put directly from Clerk-Maxwell's. The main origin of this divergence is to be found in the steady progress of knowledge in all departments of true science; even the most elementary. And, bearing this in mind, we may give an almost complete statement of the case by saying that Clerk-Maxwell's book properly belongs to the second half of the present century, while his rivals give us that of the first half only. These give us again the elementary "*Mechanics*" of our student days (more than a quarter of a century ago) very little changed—though where changed, often changed for the better—the first gives us what is emphatically the science of *to-day.* Possibly enough, in the beginning of the twentieth century even Clerk-Maxwell's book may appear a little antiquated; but it is hardly to be imagined that the text-book of that not very distant future will differ from Clerk-Maxwell's to anything like the extent to which that differs from its competitors. At least if there be anything like so a great difference it will depend upon some wholly new information as to the intimate nature of matter or energy, certainly not upon a mere difference in the mode of treatment.

The immense steps taken by Galileo and Newton (to mention only two of the chief workers) in the simplification and orderly arrangement of the fundamental conceptions and laws of physical science are too often lost sight of in comparison with the vast extensions which these men gave to our knowledge—though their actual *value* is probably little inferior. No doubt it is scarcely possible for any one (except by accident, of which some notable instances will occur to every reader) to make real extensions of our knowledge unless he possesses a clear conception of elementary principles. But great discoverers are generally too much engrossed with their higher studies to bestow much time on the explanation or co-ordination of the more elementary parts of their science. All the more honour, then, to those who, like Galileo and Newton, have made every step of their progress clearly intelligible to the student from its very foundations.

Immediately after Newton's time the progress of physical science was almost arrested in Britain (mainly, it seems, from the want of men of a high order of genius), and the really great foreign Mathematicians and Physicists of the time were entirely absorbed in the rapid development of their subjects. The disastrous consequence was that the elementary parts of science were left almost entirely to the second-rate men, or to the mere sciolists, men whose representations of science, even at the best, were mere caricatures—in the sense in which an orrery mimics the solar system, or an automaton a living animal;—and though, since that time, really first-rate men (*e.g.*, Cavendish and Young) have occasionally appeared in Britain, the pernicious influence of generations of smatterers was not easily shaken off. Thus an absurdly artificial, and unnecessarily complex system, based to a certain extent on Newton, but altogether devoid of his wonderful precision, simplicity, and completeness, came to be generally adopted here. This artificial system may be said to have reached its climax in the works of the late Dr. Whewell, perhaps the only brilliant writer of what is known now as *Paper Science*, by far the most pestilent weed against which the true scientific cultivator has to contend. The omniscient Master of Trinity might quite probably have been able to hold his own with Aristotle, had he lived in days when science had but a scanty development; but it is impossible for any one nowadays to hold relatively to human knowledge any such position. And he who tries to do so, even had he the genius of Newton to start with, will simply *do nothing*.

Clerk-Maxwell (wisely, we think) appears to prefer Newton and Rowan Hamilton to Whewell, on whom or the like of whom his rivals mainly rely. And this alone accounts for a great deal of the extraordinary dissimilarity between the works to which we have alluded. What is Whewell, the universal genius, with all his book-learning, in comparison with Newton, the special genius, with his close and patient study of material phenomena themselves? Nothing. Men consulted Whewell as they would a dictionary or an encyclopædia, simply to save themselves trouble. But when was an encyclopædia ever seen to add a volume of new matter to itself as an appendix? To use an old comparison, Newton, as it were, studied Chinese metaphysics in China itself, at head-quarters; Whewell and those who do like him read all the European works on China and all the European works on metaphysics, and "combine their information." Thus almost all Clerk-Maxwell's rivals—whom therefore we need not specially name—give us the sacred *Three Classes of Levers*, the various *Systems of Pulleys*, the altogether imaginary *gold* shell of the Florentine Academicians, the *Principle of Repulsion*, the *Transmissibility of Fluid Pressure*, and what not. Weight and specific gravity are usually put forward in preference to mass and density—the accidental property before the inherent or essential one! We have the old confusing statements about a co-efficient of *elasticity* in the impact of balls. In one of the most pretentious of these works we are told that the "strict" definition of a *level surface* implies that "at all points of it the force of gravity has the same value, and its direction is at right angles to the surface." That is to say, the author here uses the word "force" in two different senses. It means the "potential energy of a given mass," when its *value* is spoken of; but it means the "weight of a given mass" when its *direction* is spoken of. For it is inconceivable that the author could have meant to state that the weight of a body is the same at all points of a level surface. We could give without practically any limit instances of a similar kind (not mere slips of the pen, from which no man's work can be free), but we will be merciful, and simply extract the following passages, putting a word or two in italics, and leaving the reader to exercise himself in finding what is erroneous:—

> "An arrow shot upwards from a bow reaches to a certain height: show that if the weight of the arrow be doubled, *other circumstances remaining the same*, the height reached will be *one-fourth* of its former value."
>
> "Gravity and distance together represent the *force* employed from the beginning in putting things where they are, and whenever they come together by attraction they develop a corresponding *force or heat*."
>
> "When heat is continually applied to water it is found that if the water is in an open vessel its *heat cannot be raised* beyond a certain point."
>
> "The *forces* of heat, electricity, magnetism and light are now considered to be all *species of motion*, discoverable and measurable only by the amount of *movement* they can produce or counteract."
>
> ". . . water is boiled by placing a lamp beneath the flask so that the upper part of the flask becomes full of steam, the air being expelled. The flask is now stopped with a cork, removed from the lamp, and allowed to cool. . . . By pouring cold water . . the water begins to boil again. *The experiment requires great care to prevent accidents*."
>
> "Matter in motion is FORCE."
>
> "Electrical attraction is *the name given to some cases* resembling magnetic attraction, in which electricity is the agent."
>
> "Liquids possess a *small but very perfect* elasticity, which differs in amount in different liquids."
>
> ". . . gold, which *in the case of a sovereign* falls as fast as anything which we have commonly in view, may be beaten out to a thin leaf which *almost floats on* the air . . ."
>
> "*It is sometimes stated incautiously*, that the weight of a body may always be supposed to be collected at the centre of gravity, but the present case shows that *such a statement is too wide*."

There is no justifying the existence of a new way of doing anything except by showing that it is better than the old one; but, if that can be done, the new way is justified. And, as it is not our interest to become Encyclopædias, when we get a good new way, let us adopt it, and at once drop the old. And we are not without hope that Clerk-Maxwell's book may effect the complete abolition of the older methods, which are already sadly shattered. Perpetual "distinctions without a difference," like the three classes of levers above alluded to, can only confuse and irritate the student—often making him doubt whether he really understands the gist of an explanation or no. And to give rules for calculating results without explaining how to obtain these rules, or what they imply physically, is, in the vernacular, simply CRAM :—call it euphemistically what you will. To learn how to do this is not, in any sense, to acquire knowledge.

Clerk-Maxwell's book is not very easy reading. No genuine scientific book can be. But the peculiar characteristic of it is that (while any one with ordinary abilities can read, understand, and profit by it) it is the more suggestive the more one already knows. We may boldly say that there is no one now living who would not feel his conceptions of physical science at once enlarged, and rendered more definite by the perusal of it. Short and (on the whole) simple as it is, it is one of the most suggestive works we have ever met with. The following extract needs no comment of ours: let us see how the metaphysicians will digest it :—

> "But, as there is nothing to distinguish one portion of time from another except the different events which occur in them, so there is nothing to distinguish one part of space from another except its relation to the place of material bodies. We cannot describe the time of an event except by reference to some other event, or the place of a body except by reference to some other body. All our knowledge, both of time and place, is essentially relative. When a man has acquired the habit of putting words together, without troubling himself to form the thoughts which ought to correspond to them, it is easy for him to frame an antithesis between this relative knowledge and a so-called absolute knowledge, and to point out our ignorance of the absolute position of a point as an instance of the limitation of our faculties. Any one, however, who will try to imagine the state of a mind conscious of knowing the absolute position of a point will ever after be content with our relative knowledge."

We can afford space for only one other quotation ; but, as it is very important, we quote *in extenso* :—

ARTICLE CXIV.—CENTRIFUGAL FORCE.

> "This is the force which must act on the body M in order to keep it in the circle of radius v, in which it is moving with velocity V.
>
> "The direction of this force is towards the centre of the circle.
>
> "If this force is applied by means of a string fastened to the body, the string will be in a state of tension. To a person holding the other end of the string this tension will appear to be directed towards the body M, as if the body M had a tendency to move away from the centre of the circle which it is describing.
>
> "Hence this latter force is often called Centrifugal Force.
>
> "The force which really acts on the body, being directed towards the centre of the circle, is called Centripetal Force, and in some popular treatises the centripetal and centrifugal forces are described as opposing and balancing each other. But they are merely the different aspects of the same stress."

This is one of the few passages in the work to parts of which exception may fairly be taken. Of course, the *physical* statements are correct, and they are very clearly put. But it is hardly fair to a junior reader to begin by telling him that Centrifugal Force means *the force which must act* on a body in order to keep it moving in a circle, and then to say that *the force which really acts* is called Centripetal Force ! That force is required *to produce change of direction* of a body's motion, and that when this is applied by means of a string held in the hand the impression on our "muscular sense" is the same as if the body were *pulling* at the other end of the string, are facts : but they no more justify the use (however guarded) of the word "centrifugal" than the tension of the couplings, just before a train starts, proves that the carriages have a tendency to run *backwards*.

There is one very great blemish in Clerk-Maxwell's book, from which those of his rivals are comparatively free. Some of the woodcuts are simply atrocious. This must be looked to in future editions, for passages of great importance are at present rendered totally unintelligible to the beginner : and from this cause alone.

Clerk-Maxwell's work, then, is simply Nature itself, so far as we understand it. The peaks, precipices, and crevasses are all there in their native majesty and beauty. Whoso wishes to view them more closely is free to roam where he pleases. When he comes to what he may fear will prove a dangerous or impassable place, he will find the requisite steps cut, or the needful rope attached, sufficiently but not obtrusively, by the skilful hand of one who has made his own roads in all directions, and has thus established a claim to show others how to follow.

In the rival elementary works the precipice and the crevasse are not to be seen : there are, however, many pools and ditches ; for the most part shallow, but *very* dirty. You are confined to the more easily accessible portions of the region. In the better class of such books these are trimly levelled—the shrubs and trees are clipped into forms of geometrical (*i.e*, unnatural) symmetry like a Dutch hedge. Smooth straight walks are laid down leading to old well-known "points of view,"—and, as in Trinity of ormer days, undergraduates are warned against walking on the grass-plats.

These "royal roads" to knowledge have ever been the main cause of the stagnation of science in a country. He would be a bold man indeed who would venture to assert that the country which, in times all but within the memory of many of us, produced such mighty master-minds as Lagrange, Fourier, Ampère, and Laplace, does not now contain many who might well have rivalled the achievements even of men like these. But they have no chance of doing so ; they are taught, not by their own struggles against natural obstacles, with occasional slight assistance at a point of unexpected difficulty, but by being started off in groups, "eyes front" and in heavy marching order, at hours and at a pace determined for all alike by an Official of the Central Government, along those straight and level (though perhaps sometimes rough) roads which have been laid down for them ! Can we wonder that, whatever their natural fitness, they don't now become mountaineers ?

I still vividly remember the horror with which I watched the the struggles of a former class-fellow of my own, whose friends had just sent him to another school that he might learn geometry a little earlier than was the custom with us. For him there was no longer any play—

all his spare time was devoted to the committing of Euclid to memory! I shuddered as I thought of what was to be my own fate in a few short months, when I too must be subjected to this fearful imposition. But the first hour or two which Dr. Gloag (a name strange, perhaps, to southern ears, but very high indeed on the roll of successful teachers—Clerk-Maxwell, indeed, was one of his pupils) devoted to geometry showed those of us who had any taste for the subject that it was one to be learned by head, not "by heart" (the idiotic phrase in common use)—and that my friend's parents had simply taken him from a good teacher and sent him to an exceedingly bad one—for it came to be discovered after some time that he had really considerable aptitude for geometry.

But if he had been in fact quite unfit for the study, otherwise than in learning to repeat Euclid by rote, what object beyond mere torture would have been attained by forcing it upon him? This leads to another remark of great importance in connection with the mass of elementary text-books.

What sort of students are those who require to be told to *take the square of the velocity, divide it by the radius, and find the proportion of this quotient to* 32 . . . :—without farther explanation or proof? What the better are they of the information? Call you this "teaching science?" Has it improved their minds? Will they be able to make any use of it in after life? I do not see how these questions and many other connected ones can be answered except by a prompt negative. One of two things. The pupil who requires to be taught in this way is either as yet too young, or is one who will never become old enough, to learn even the rudiments of science.

To our metaphor once more. Grass-plats, moss, and flower-beds for the happy sports of children—the bare rock and rough moor for the stern work of men. Your gravel-walks and Macadamised roads are excellent things in their way, but keep them to their legitimate users, the carriage and the perambulator for the invalid and the infant who can neither work nor even play.

My reasons for writing on this subject are very serious ones. I have to consider each year how best to instruct some couple of hundred students in the elements of physics, and have to be constantly on the out-look for a really good text-book of an elementary character. In the higher branches of the subject there is, happily, little difficulty, but that a really good, short, and simple treatise on the merest elements has been (at least till very lately) wholly unprovided is, I think, clear from the ridiculous discussions about *Centrifugal Force*, and other connected ideas, which are even now constantly to be found in our more practical periodicals. P. G. TAIT

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.]

Nectar-Secreting Glands

MR. FRANCIS DARWIN has made an interesting addition to his important discovery of nectar-bearing glands on the young fronds of *Pteris aquilina*, supplied from the ever-welcome experience of Mr. Fritz Müller. The latter gentleman finds that in Brazil the *Pteris aquilina* is protected from the leaf-cutting ants by those attracted to the nectar, and Mr. Darwin adds some speculations on the origin of the glands and their continued functional activity in Europe where they now appear to be useless. On this part of the question I should like to make the following remarks :—

Prof. Heer has shown that in the Miocene plant-beds at Œningen and Radoboj, ants are the most numerous amongst the fossil insects, and in 1849 as many as sixty-six species had been described from these two localities. In 1865 the number found at Œningen alone is recorded as forty-four. I do not know what the total number of species is that have been recorded from the two places up to the present time, but it probably does not fall short of eighty. Amongst the fossil ants from Radoboj there are species of the Tropical American genera *Atta* and *Ponera*. One of the fossil species of *Atta* resembles in general form and in the venation of the wings the curious *Atta cephalotes* of Tropical America.

As there are only about forty species of ants existing now in the whole of Europe it is evident that in the Miocene epoch they must have played a much more important part in Europe than they do now. Plants may then have been exposed to the attacks of enemies that have become extinct along with the general impoverishment of the fauna and flora of Europe that took place in Post-pliocene times; and the protection afforded by ants attracted to the nectar-bearing glands at the critical stage of the unfolding of the young and tender leaves may have been as important to some plants in Europe, then, as it is to many in Tropical America now.

With regard to the persistency of the nectar-producing glands up to the present time in Europe, it is to be remarked that many plants are identical with those living in the Miocene period and the world-wide distribution of *Pteris aquilina* seems to indicate that it is of very ancient origin. If a plant has not otherwise varied there is no reason apparent why it should do so in this respect so long as the secretion of nectar is not positively injurious to it. I have recently noticed in my garden that the ants that attend the glands at the bases of the leaves of the cherry, the plum, the peach, and the apricot, stroke with their antennæ some of the glands that are not excreting when they arrive at them, just as they do the bodies of the aphides. I have not actually noticed that this promotes a flow of nectar, but ever since I became a disciple of Darwin I have been convinced that the most trivial circumstance is worthy of notice; and it may be that the slight irritation of the glands kept up by the ants is sufficient to ensure the perpetuation of a function of the plant now useless to itself. It is, however, perhaps too soon to assume that the glands are entirely useless to the plants in Europe. Darwin states that there is good evidence that the absence of glands in the leaves of peaches, nectarines, and apricots leads to mildew ("Animals and Plants under Domestication," vol. ii. p. 231).

Darwin refers at the same place to the variation of the glands of the leaves in the above-mentioned fruit trees and I may add that they are extremely variable on the cherry, being sometimes absent, sometimes on the stalk and sometimes on the blade of the leaf. The young leaf in its earliest stage, before it expands, has a complete fringe of them, thus bearing out Mr. Francis Darwin's theory that they are homologous with the serration-glands of Reinke.

May I suggest to some of your correspondents that information as to how far north in Great Britain or in Europe the glands on the above fruit trees are attended by ants and especially if the wild cherry (which I have not had an opportunity of observing) is so attended, would be of great interest. THOMAS BELT

Cornwall House, Ealing, June 8

On Time

"The fact is, that we have not yet quite cast off the tendency to so-called metaphysics."—Tait, "Rec. Adv. in Phys. Sc.," p. 11.

IN Thomson and Tait's "Natural Philosophy," of which I have only the German edition in my possession, I find, § 246 : "Die Zeiten, während welcher irgend ein besonderer Körper, der durch keine Kraft angetrieben wird, die Geschwindigkeit seiner Bewegung zu ändern, gleiche Wege durchläuft, sind einander gleich." And § 247 : "Dieser Satz drückt bloss die für die Messung der Zeit allgemein getroffene Uebereinkunft aus."

These quotations quite express what is generally understood.